

PCT

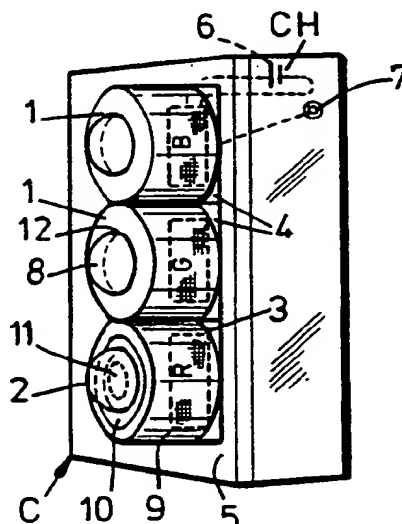
WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification⁵ : H04N 5/335, 9/097, 5/225</p>	<p>A1</p>	<p>(11) International Publication Number: WO 93/11631 (43) International Publication Date: 10 June 1993 (10.06.93)</p>
<p>(21) International Application Number: PCT/GB92/02260 (22) International Filing Date: 4 December 1992 (04.12.92) (30) Priority data: 9125954.9 6 December 1991 (06.12.91) GB (71) Applicant (for all designated States except US): VLSI VISION LIMITED [GB/GB]; Technology Transfer Centre, King's Buildings, Mayfield Road, Edinburgh EH9 3JL (GB). (72) Inventor; and (75) Inventor/Applicant (for US only) : DENYER, Peter, Brian [GB/GB]; 91 Colinton Road, Edinburgh EH10 5DF (GB). (74) Agents: McCALLUM, William, Potter et al.; Cruikshank and Fairweather, 19 Royal Exchange Square, Glasgow G1 3AE (GB).</p>		<p>(81) Designated States: GB, JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>

(54) Title: SOLID STATE SENSOR ARRANGEMENT FOR VIDEO CAMERA



(57) Abstract

The present invention relates to an image capture system suitable for use in an electronic camera system *C* and comprising a solid state image capture device (1) comprising an integrated circuit (5) having at least two sensor arrays (4), each said array having an image sensing surface (3) and a respective lens system (8) associated therewith.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	MR	Mauritania
AU	Australia	GA	Gabon	MW	Malawi
BB	Barbados	GB	United Kingdom	NL	Netherlands
BE	Belgium	GN	Guinea	NO	Norway
BF	Burkina Faso	GR	Greece	NZ	New Zealand
BG	Bulgaria	HU	Hungary	PL	Poland
BJ	Benin	IE	Ireland	PT	Portugal
BR	Brazil	IT	Italy	RO	Romania
CA	Canada	JP	Japan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SK	Slovak Republic
CI	Côte d'Ivoire	LI	Liechtenstein	SN	Senegal
CM	Cameroon	LK	Sri Lanka	SU	Soviet Union
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	MC	Monaco	TG	Togo
DE	Germany	MG	Madagascar	UA	Ukraine
DK	Denmark	ML	Mali	US	United States of America
ES	Spain	MN	Mongolia	VN	Viet Nam
FI	Finland				

SOLID STATE SENSOR ARRANGEMENT FOR VIDEO CAMERA

The present invention relates to electronic cameras including electronic colour cameras.

It is well known that colour sensors can be produced by discriminating three images of the primary colours (blue, green, red) of the scene. All colours can be analysed and synthesised via these primaries (or other complementary triples like cyan, magenta, yellow). Conventional electronic cameras classically use one of two approaches for forming the separate colour images. 3-tube cameras use a single lens followed by a prism which forms three separate r.g.b images. Three sensors are used simultaneously to detect these three images. If the sensors are accurately aligned the resulting picture is of very high quality. However the sensors are separated in space and orientation and their assembly and alignment with the prism and lens is difficult for a volume manufacturing process. This technique is therefore used exclusively for expensive broadcast-quality equipment. Colour-Mosaic Cameras use a single lens and sensor, but the sensor surface is covered with a high-resolution mosaic or grid of colour filters, with the pattern dimension equal to the pixel-pitch for a semiconductor CCD or MOS sensor array. Pixels of different colours are demultiplexed at the sensor output and interpolated to form synchronous parallel colour signals. This is well-suited to volume production as the surface colour mosaic can be fabricated as an extension of the semiconductor wafer fabrication process. The techniques for mosaic fabrication are restricted to relatively few companies worldwide who supply the colour sensor market and thus they are not commonly available. Furthermore, associated with this technique there are technical problems concerned with resolution and aliasing. Much

work has been done to correct these effects, but usually at some cost in image-processing hardware.

It is an object of the present invention to avoid or minimise one or more of the above disadvantages.

- 5 In one of its broadest aspects, the present invention provides an image capture system comprising a solid state image capture device which device comprises an integrated circuit having at least two sensor arrays, each said array having an image sensing surface and a
10 respective lens system associated therewith.

Thus in effect the present invention provides two or more cameras on one chip each with its own lens system and sensor array. With such an arrangement the problem of alignment is greatly reduced by the fabrication of
15 the various sensors required on one chip. This ensures that the sensors all lie in the same plane and have the same rotational orientation, and this is an important advantage. Assuming lenses can be accurately assembled in a parallel plane (see below), the only alignment
20 errors which are likely to occur are simple orthogonal translations in the form of vertical and horizontal errors in the centres of the optical axes. It is relatively easy though to calibrate these cameras after assembly and electronically to correct for these
25 translations. Whilst the inevitable lateral off-set between the cameras at even the closest dispositions of the cameras on the chip, will of course give rise to a degree of parallax error, it has now been found that with a preferred system of the present invention with
30 generally adjacent sensor arrays, the degree of error in producing a single composite image (i.e. a single image produced by the more or less accurately aligned super imposition of two or more corresponding images e.g. at

different wavelengths, of the same scene) can be acceptably small for small camera geometries for low to medium resolution applications. Thus in said one preferred aspect the present invention provides a
5 composite image camera of particularly simple and economic construction.

The present invention also provides in another aspect a stereoscopic image capture system where larger sensor spacings are used to provide a greater parallax
10 differential for producing different images with a more or less accurately defined parallax differential for use in producing stereoscopic image pairs. Again the use of two or more cameras mounted on a single chip helps substantially to minimise alignment problems in
15 producing an accurate stereoscopic view.

Advantageously the lens systems are mounted substantially directly on the image sensing surfaces. Preferably there is used a lens system in accordance with our earlier British Patent Application No.
20 9103846.3 dated 23rd February 1991 (published in International Publication No. WO92/15036) which lens comprises a lens and a spacer in substantially direct contact with each other, said spacer preferably having a refractive index not less than that of said lens, said
25 lens and spacer having refractive indices and being dimensioned so as to form an image in a plane at or in direct proximity to a rear face of said spacer element remote from said lens element, from an object, whereby in use of the lens system with said lens system mounted
30 substantially directly on the image sensing surface of the image capture device an optical image may be captured thereby.

These lens systems have the advantage of physical dimensions which can be made similar to those of the sensor array itself, so that sensors and lenses may be immediately adjacent to each other. Camera separations
5 as low as 2 to 3mm are easily achieved and this helps to minimise the parallax error. The flat surfaces of the cylindrical lens spacer also help to maintain accurate planarity for groups of lenses attached to the same chip substrate.

10 It is also possible though to use more conventional, albeit similarly small, lens systems which are mounted on a suitable support so as to be spaced from the sensor surface with an air gap therebetween. One advantage of such systems is that they allow the use of more
15 conventional and cheaper lens materials without the need for special materials having particular refractive indices.

In general at least one of the individual cameras constituted by respective lens system and sensor arrays,
20 is provided with a filter means for passing a desired wavelength (or wavelength range) of the electromagnetic radiation spectrum, whereby there may be captured a composite image comprised of two or more (depending on the number of individual cameras used) images of the
25 same object differing substantially only in the wavelength thereof.

In one preferred form of the invention the integrated circuit has three sensor arrays provided with respective lens systems and filters for three different wavelengths
30 e.g. red, green, and blue, or cyan, magenta, and yellow for providing a desired composite image e.g. a full-colour image.

Where three or more individual cameras are used, it will be appreciated that various different layouts of the sensor arrays relative to each other may be employed including e.g. linear arrangements or generally

5 "circular" or other close-packed arrangements.

In cameras using the 3 primary colours, green is dominant in providing image acuity since it generally dominates the derived luminance. In all cases therefore, the green camera is desirably made as central

10 as possible, and the red and blue cameras are referenced to it. The parallax errors will therefore show up on red and blue only.

With reference to lens systems of our earlier application No. 9103846.3, the expression "substantially

15 direct contact" is used to mean that there should not be any significant interspace containing low refractive index material such as air i.e. no interspace having a thickness resulting in a significant optical effect. In the case of an air gap this should normally be not more

20 than 500 um, preferably not more than 100 um, thick, In the case where resin or like material is used between the components adhesively to secure them together and has a refractive index comparable to that of the lens or spacer, it may be considered as an extension of the lens

25 or spacer and thus need not be so restricted in thickness though preferably the thickness thereof should not be excessive and should be more or less similarly restricted.

Advantageously there is used a plano-convex (or possibly

30 plano-concave - see below) lens with a substantially plane spacer for manufacturing convenience and economy but other combinations e.g. a bi-convex lens and a plano-concave spacer, may also be used.

Preferably the lens system is secured to said image sensing surface by an optical grade adhesive i.e. a substantially transparent optically uniform adhesive. Desirably there is used between the lens and spacer an
5 adhesive having the same refractive index as the lens (or if preferred, as the spacer) and between the spacer and the sensing surface, an adhesive having the same refractive index as the spacer.

Preferably the spacer has a higher, most preferably a
10 substantially higher, refractive index than the lens. Where the same refractive index is acceptable for both then it will be appreciated that the spacer could be formed integrally with the lens.

It will be appreciated that the radius (or radii) of
15 curvature of the lens element and its refractive index may be varied through a wide range of values depending on the required performance in terms of depth of field, image size, freedom from aberrations etc. In general there will desirably be used solid state image capture
20 devices in the form of photoelectric sensor arrays (wherein photons are used to generate electric current and/or voltage or change electrical properties such as resistance etc.) which have relatively small size image sensing surfaces e.g. in the range from 0.1 to 5 cms
25 across. Thus the lens system should in such cases desirably be formed and arranged to provide a similarly small-sized image. Where a wide angle field of view is also required (e.g. in surveillance applications), then a lens of relatively short focal length should be used
30 e.g. for a field of view angle of 80 degrees the (maximum) focal length will not normally exceed 1.19 times the image height and for 60 degrees will not normally exceed 1.73 times the (maximum) image height,

the (maximum) image height corresponding to half the sensing surface diameter. The use of a high refractive index spacer and the exclusion of any low refractive index material from the optical path significantly decreases aberration due to Petzval Curvature (otherwise known a curvature of field aberration) and limits spherical aberration. The lens system is therefore particularly advantageous in wide field and/or large aperture applications required for low light conditions. In general there is desirably used, for such wide angle applications, a lens element having a refractive index n_{nd} in the range from 1.45 to 1.65, and a spacer element with a higher, refractive index n_{nd} in the range from 1.45 to 1.85.

Various optical grade materials having suitable refractive indices are widely available. Low-dispersion glass such as type BK7 (available from various sources e.g. Schott Glaswerke) is particularly suitable for the lens element. The spacer element may be made of LaK10 glass also readily available. Other materials that may be used for the lens and/or spacer elements comprise plastics materials, although these are generally less preferred in view of their lower resistance to scratching and other damage and the lower refractive indices available. Nevertheless they may be acceptable for certain applications requiring low cost such as consumer door-entry and security cameras.

Suitable adhesive materials for use between the spacer and lens elements and between the spacer element and the solid state image capture device include optical grade epoxy resins.

In a preferred image capture system of the present invention the solid state image capture device comprises

an integrated circuit image array sensor such as that disclosed in our earlier International patent application No. PCT/GB90/01452 (publication No. WO91/04633 the contents of which are hereby incorporated
5 herein by reference thereto) which has on-board signal processing means formed and arranged for directly providing a video signal output. Naturally though other image capture devices such as CCD, MOS and CCD sensors may also be used. Also the image capture device may
10 comprise simply a sensor chip on which are only provided the sensor arrays with all the electronic circuitry required to detect the response of individual sensor cells to incident radiation and further processing of the detected response provided externally of the sensor
15 chip, and of course other arrangements with a greater or lesser part of this electronic circuitry provided on the chip bearing the sensor arrays, are also possible. Accordingly references to "cameras" herein includes references to apparatus in which substantially the whole
20 of the electronic circuitry required to produce a video output signal is provided on the same chip as the sensor arrays, as well as apparatus in which a greater or lesser part is provided separately. Thus references to camera alignment relate only to alignment of the lenses
25 and sensor arrays (and not to any other components that may be required to produce a video signal output.

Thus using miniature, chip-mounted lenses, it is possible to fabricate multiple independent cameras on single VLSI chips. These cameras accurately lie in the
30 same plane and are rotationally in substantially perfect alignment. Any remaining alignment errors are primarily translational and can be easily corrected by retiming the readout control sequences.

Further preferred features and advantages of the present invention will appear from the following detailed description by way of example of a preferred embodiment illustrated with reference to the accompanying drawings

5 in which:

Fig. 1 is a schematic perspective view of a composite image colour video camera of the invention with three individual camera units;

10 Figs 2(a) to (d) are schematic views showing 4 different 2-D arrangements of the three camera elements relative to each other;

Fig. 3 is a schematic illustration of the optical performance of a camera of the invention;

15 Fig. 4 is a block circuit diagram of one possible electronic architecture for a camera of the invention;

Fig. 5 is a sectional elevation of another camera of the invention; and

Fig. 6 is a schematic perspective view of a spacer support element suitable for use in the camera of Fig. 5.

20 Fig.1 shows a miniature colour video camera system C having three cameras 1 each comprising a lens system 2 mounted directly onto the image sensing surface 3 of a respective solid state image capture device in the form of an integrated circuit image array sensor 4. The
25 sensors 4 are formed as separate sections of a single monolithic VLSI microchip 5 mounted in a suitable housing CH containing a power supply 6 and provided with a video signal output interface 7.

30 In more detail the lens system 2 comprises a generally hemispherical lens 8 having a radius of curvature of the order of 0.85 mm, and a cylindrical spacer element 9 of substantially larger diameter (ca. 1.7mm) and a length of 1.59 mm, with an aperture stop 10 therebetween. The aperture stop 10 is of metal e.g. steel alloy with a

thickness of 0.15 mm and an iris diameter of 0.8 mm providing an effective lens aperture of f2.0. The aperture opening is filled with clear epoxy resin 11 which has a refractive index substantially similar to that of the lens 8 and secures the lens 8 and spacer 9 to each other and to the aperture stop 10. Alternatively an aperture stop of metal or other material could simply be printed onto the spacer or lens e.g. using a photolithographic technique. The R, G, B (red, green and blue) filters 12 for the three respective lenses 8 can also be disposed between the lenses 8 and spacers 9.

The lens 8 is of low dispersion glass (Bk7) having a refractive index n_d of 1.568 and the spacer is of LaK10 glass which has a higher refractive index n_d of 1.7200. This combination produces low image blur and large image size (ca. 1.4mm image height from central axis). The spacer 9 has a length of around 1.59mm. This lens system has an effective depth of field of from 2cms to ∞ with a field of view angle of 90° and has an rms blur of around 5 μ m which is within the unit sensor pixel dimensions thereby providing a reasonably good video signal image output from the video signal output connection 7.

It will be appreciated that various modifications may be made to the above described embodiment without departing from the scope of the present invention. Thus for example the spacer element could be a composite element made up of a plurality of plane components. The lens element could also be composite though this would normally be less preferred due to the significantly increased complexity. The various surfaces of the lens system could moreover be provided with diverse coatings for e.g. reducing undesirable reflections and selective

filtration of the incident light rays in generally known manner. Also the R, G, B filters could be mounted on a suitable support in front of the lenses 8 as further described hereinbelow.

- 5 Fig. 2 shows some possible alternative layouts for the individual cameras on the single chip. In layout (a) the absolute red-green and blue-green distances are minimised. All of the parallax error is vertical. This may not be optimum for TV applications, as in this case
10 the colour signal is greatly averaged horizontally, but not at all vertically. Layout (b) forces all of the parallax error into the horizontal dimension to take advantage of this. Layout (c) has slightly worse red-green and blue-green parallax than (a), but the
15 red-blue distance is greatly less. Intuitively, this configuration minimises the total parallax error. Layout (3) is as for (c), but pushes most of the r-g, b-g errors into the horizontal axis.

- Apart from its substantial simplicity, the colour camera
20 system of the present invention provides two further potential technical advantages over the alternative known approaches. Axial colour aberration causes the focal plane for blue to be slightly closer to the lens, and for red slightly further from the lens, than green.
25 This aberration may actually be an advantage if we design the lens for green light and the blue and red images become slightly defocussed, thereby also blurring the effect of parallax errors. For ordinary glasses, the blue and green images are blurred by around 1 pixel
30 at the geometries used above. If we wish, the 3-lens approach could be adapted to accommodate this aberration by fine-tuning the focal length of each lens. This is impossible with either of the existing single-lens approaches. Transversal colour aberration is a change

in magnification factors at different wavelengths.
Again it may be possible to correct for this by
modifying slightly the red and blue lens geometries.

Fig. 3 shows how the parallax errors between closely
5 adjacent identical cameras can be maintained at or below
one pixel for cameras with useful resolutions of several
hundred pixels. If the cameras are calibrated to
provide image alignment for objects at infinity, then an
object at distance 0 (on the optical axis of one camera
10 for simplicity) is imaged at an offset of e pixels in
the second camera. It is obvious that the parallax
error is greatest for objects which are closest to the
cameras. To help in generalising the result, suppose we
wish to image objects at minimum range O_{mm} with a field
15 of view of 2θ degrees and sensor resolution of P
pixels. Then by trigonometry, the parallax error e , in
pixels, is:-

$$e = P.s / 0.2 \tan (\theta) \text{ pixels} \quad (1)$$

where s is the camera separation. This important result
20 is independent of the focal length of the lens and shows
that the error is reduced by lowering s , lengthening O
or increasing θ .

Actually, e in equation (1) is the parallax error for a
close object with reference to objects at infinity.
25 Advantageously we might calibrate the cameras to provide
alignment for objects at some mid range and achieve a
balance of errors between close and far objects. It is
easy to show that if we calibrate on objects at range
 $2x_0$ then the worst case parallax error for near and far
30 objects is:-

$$e' = P.s / 0.4 \tan (\theta) \text{ pixels} \quad (2)$$

Thus in the case of a colour camera for computer vision using a typical standard resolution of e.g. 240 x 320 pixels, then if we require a lens with 52° angle-of-view ($\phi = 26^\circ$), horizontal resolution, P, of 320 pixels, minimum range O, of 50cm and we achieve a separation, s, of 3mm, e' will be slightly less than one pixel. In the case of a low resolution colour camera for video telephones using the QCIF standard (144 x 178 pixels), this device must work at close range, say down to 25cm. Say we use the same angle of view, 52°, and achieve a lens separation of 1.5mm (allowing for the smaller array), then the error in this case will be approximately 0.5 pixels. In both cases, the parallax error is less than one pixel and therefore of the same order as aliasing and interpolation errors in single-chip colour mosaic cameras and accordingly reasonably acceptable.

Conversely it will be appreciated that where it is desired to capture stereo images the parallax error and should be greater than 1. It may be seen from the above equations that parallax error increases for small object ranges or distances O and for larger camera separations s. With a sensor size P of 240 pixels, camera pitch separation s of 3.1mm, and field of view of 45° (2ϕ), stereo image capture is feasible at ranges up to 1.8 metres. This range can be increased simply by corresponding increases in the camera separation s.

The electronic architecture of the camera is substantially independent of the optical and sensor arrangement described above. Nevertheless, the availability of synchronous, continuous RGB colour signals minimises the required image processing. This results in a simpler and lower-cost electronic

implementation than for colour-mosaic cameras.
Furthermore, the electronic requirements may be
implemented feasibly on the same chip as the sensors
where CMOS sensor technology such as that described in
5 our earlier Patent Publication No. WO91/04498, is used.

Figure 4 gives an overview of one possible electronic
architecture. Three colour arrays are driven in similar
style to a monochrome array, except that the timing of
vertical and horizontal control on the red and blue
10 arrays is altered by offset values loaded into the
controller from an off-chip PROM (Programmable Read Only
Memory) Chip which has been programmed with the offset
calibration data.

Automatic Exposure Control (AEC) is provided as for
15 monochrome arrays. The same exposure value is used for
all three arrays. Exposure is monitored via the green
output alone, or possibly by deriving luminance from a
combination of RGB signals.

Automatic Gain Control (AGC) is also provided as for
20 monochrome arrays, but in this case, independent gains
can be set for each colour. AGC provides three
functions:-

(i) automatic peak level calibration using a saturated
reference line in the Green array. In normal exposure
25 circumstances, the gain of the green channel is fixed at
this value and this forms a nominal gain for the red and
blue channels also.

- (ii) dynamic colour balancing to correct for variations in the colour of ambient light by adjusting the blue and red gains according to colour analysis of the three channels.
- 5 (iii) automatic gain of weak images in low light conditions when AEC has reached maximum exposure. At first dynamic colour balancing can continue, but at the lowest light levels (maximum gain), flexibility may be lost. This is characteristic of many colour cameras.
- 10 The resulting balanced colour signals are passed through a colour correction matrix, which performs weighted mixing of the three colours (see e.g. D'Luna and Parulski, IEEE JSSC Vol. 26, No. 5, pp. 727-737) followed by gamma correction on each colour. Both these
- 15 functions are standard requirements for colour cameras intended for TV displays as they correct for known colour and amplitude nonlinearities in the display tubes.

The matrix may be implemented in analogue CMOS, either by using switched capacitors or switched

20 current-sources. Either of these can accommodate alterable coefficients in digital form, or they could be fixed in layout. In the former case the coefficients may be stored in the PROM already provided for offset calibration and this may afford a useful degree of

25 flexibility.

The gamma corrected RGB signals are then passed to an appropriate encoder for whatever standard is required. Suitable encoders for e.g. NTS/PAL are readily available.

In Figs. 5 and 6 like parts corresponding to those in

30 Fig. 1 are indicated by like reference numerals. The Figs. 5 and 6 illustrate an alternative embodiment in which is used a lens system 20 supported at its edges 21

on spacer elements 22 with a substantial free air space 23 between the three lenses 8 of the lens system and the respective sensors 4. In more detail, the lens system 20 is a one-piece moulding from a suitable optical grade plastics material and incorporating an array of three lens portions 8 joined edge-to-edge. It will be appreciated that this affords a particularly economic and convenient form of production whilst at the same time simplifying assembly of the camera insofar as the three lenses for the R, G, B components of the image, are automatically aligned with each other. Nevertheless it will be understood that, if desired, the lenses 8 could be manufactured from other materials e.g. glass or any other suitable optical material and/or as discrete individual components. Moreover each lens could comprise more than one element e.g. a doublet. The lenses 8 may conveniently be aspheric or spherical or planar at either surface thereof.

As in the first embodiment, the sensors 4 are formed as separate sections of a single monolithic VLSI microchip 5, mounted in a housing CH (only part shown). An optical support sub-housing 24 has various shoulder portions 25-28, for respectively securing the monolithic chip 5 to the housing CH, supporting the lens system 20 on the spacer elements 22 above the chip 5, supporting R, G and B filters 29-31 above the lenses 8, and supporting a protective outer Infra Red filter 32 (conveniently of doped glass e.g. Schott KG3 or BG39). Additional support to the lens system 21 and the filters 29-31 is conveniently provided by spacer walls 33, 34 which have the further advantage of acting as light baffles between the three, R, G, B, cameras 1 to prevent cross-imaging between each lens 8 and the other sensors 4. As shown in Fig. 6 the lower spacer walls 33 may conveniently be formed integrally with the support sub-housing 24.

It will be understood that various modifications may readily be made to the above described embodiment.

Thus, for example, the order of the filters 29-31 and 32 may be changed.

CLAIMS

1. An image capture system comprising a solid state image capture device which device comprises an integrated circuit having at least two sensor arrays, each said array having an image sensing surface and a
5 respective lens system associated therewith.
2. A system according to claim 1 in which system at least one of the lens systems is mounted spaced apart from the sensor means with a fluid medium between the lens and the sensor.
- 10 3. A system according to claim 1 in which system at least one of the lens systems, comprises a lens in substantially direct contact with a transparent spacer in substantially direct contact with the sensor and
15 extending between said lens and sensor, said lens and spacer having refractive indices and being dimensioned so as to form an image in a plane at or in direct proximity to a rear face of said spacer element remote from said lens element, from an object, whereby in use of the lens system with said lens system mounted
20 substantially directly on the image sensing surface of the image capture device an optical image may be captured thereby.
4. A system according to claim 3 wherein said spacer has a refractive index not less than that of said lens.
- 25 5. A system according to any one of claims 1 to 4 wherein at least two said lens systems are formed integrally with each other.
6. A system according to any one of claims 1 to 5 wherein said sensor arrays are photoelectric.

7. A system according to claim 6 wherein each sensor array has a diameter of from 1 to 10mm.
8. A system according to any one of claims 1 to 7 which has a pair of sensor arrays spaced apart so as to
5 provide a stereo image capture system for objects within a predetermined range from the camera.
9. A system according to any one of claims 1 to 7 which has at least three sensor arrays and wherein at least one of the respective lens systems is provided with a
10 wavelength selective filter means, so as to provide a composite image capture system.
10. A system according to claim 9 wherein are provided three sensor arrays and in which the respective lens systems are provided with red, green, and blue filters,
15 whereby substantially full colour composite image capture may be effected.
11. A system according to claim 9 wherein are provided three sensor arrays and in which the respective lens systems are provided with cyan, magenta and yellow
20 filters, whereby substantially full colour composite image capture may be effected.
12. A system according to any one of claims 9 to 11 wherein said sensor arrays are arranged in a linear array.
- 25 13. A system according to any one of claims 9 to 11 wherein said sensor arrays are arranged in a close-packed non-linear array.

14. A system according to any one of claims 9 to 13 wherein said sensor arrays are disposed at a pitch spacing of not more than 5mm.

15. A system according to any one of claims 1 to 14
5 wherein are used wide angle lens systems having a field of view of at least 60°.

16. A video camera having an image capture system according to claim 8 or any of claims 7 to 15 when dependant on claim 6.

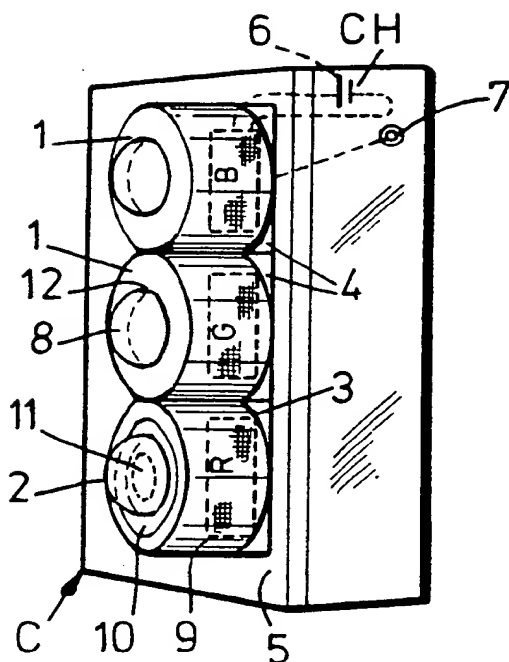


FIG. 1

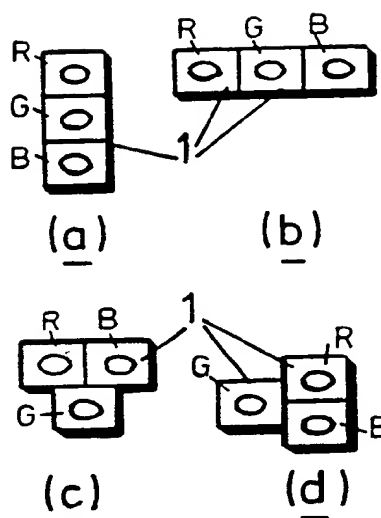


FIG. 2

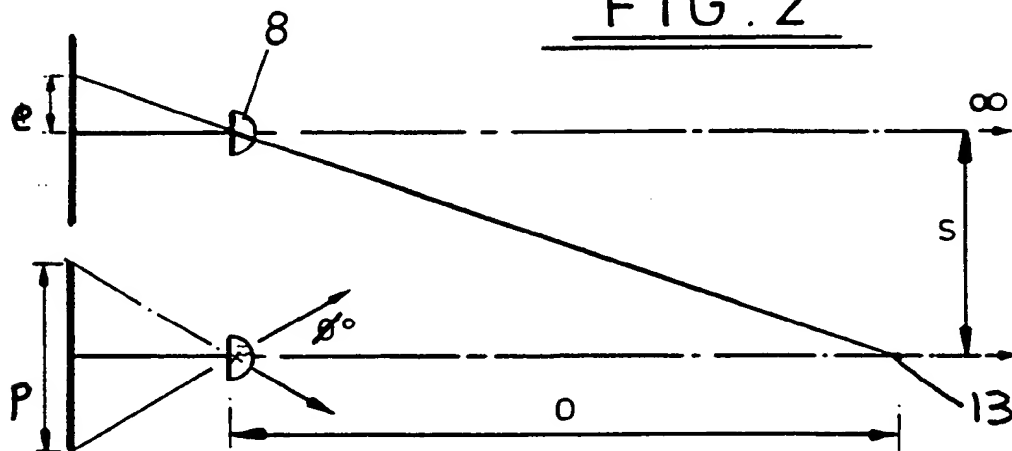
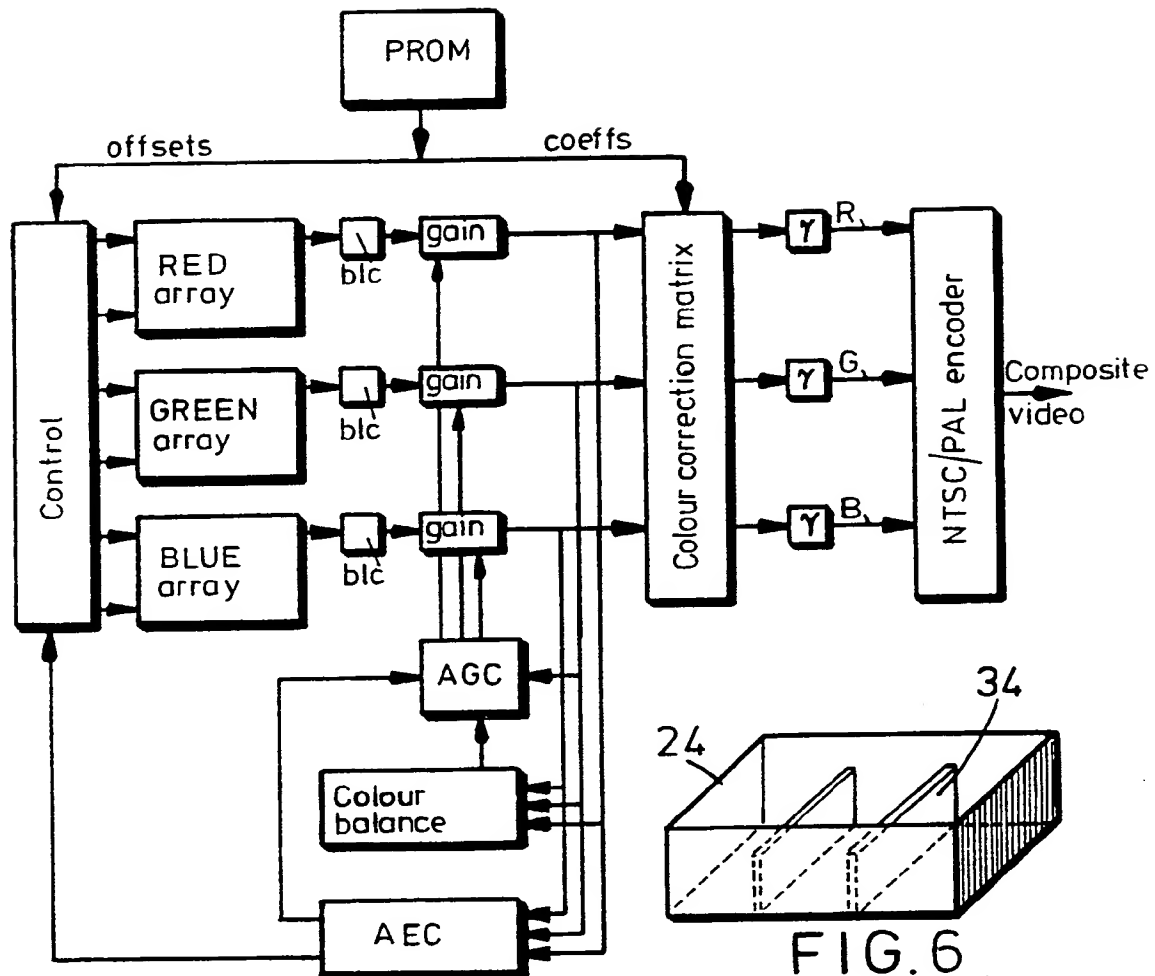
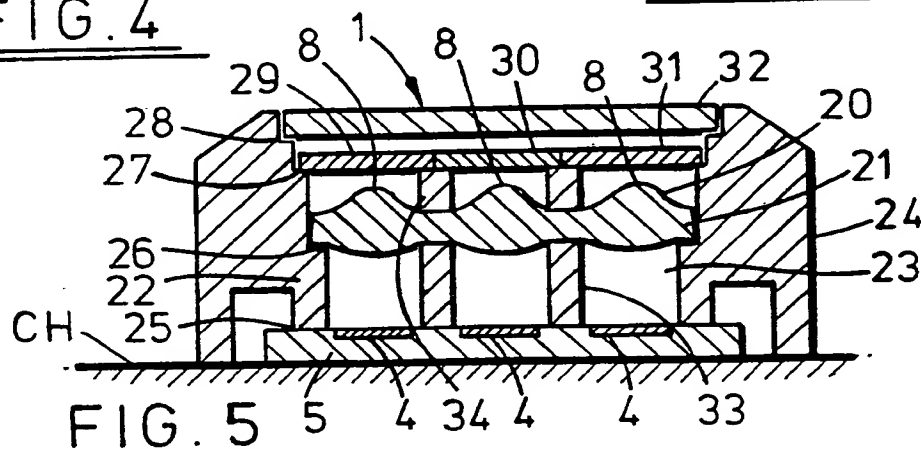


FIG. 3

FIG. 4FIG. 6FIG. 5

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 92/02260

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC Int.Cl. 5 H04N5/335; H04N9/097; H04N5/225		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. 5	H04N	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	GB,A,2 240 444 (PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED) 31 July 1991 see page 3, line 12 - line 26 see page 7, line 10 - line 19 see page 8, line 30 - page 9, line 7 see page 9, line 26 - line 30 see page 14, line 11 - line 25 ---	1,2,3,5, 6
Y	EP,A,0 248 687 (SOCIETE NATIONALE INDUSTRIELLE AEROSPATIALE) 9 December 1987 see column 1, line 46 - line 57 see column 2, line 22 - line 34 --- -/--	1,2,3,5, 6
<p>¹⁰ Special categories of cited documents : ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search 24 MARCH 1993		Date of Mailing of this International Search Report 01.04.93
International Searching Authority EUROPEAN PATENT OFFICE		Signature of Authorized Officer BEQUET T.P.

Form PCT/ISA/210 (second sheet) (January 1985)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		Relevant to Claim No.
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	
A	PATENT ABSTRACTS OF JAPAN vol. 6, no. 259 (E-149)(1137) 17 December 1982 & JP,A,57 157 683 (CANON K.K) 29 September 1982 see abstract ----	1
A	PATENT ABSTRACTS OF JAPAN vol. 9, no. 178 (E-330)23 July 1985 & JP,A,60 047 560 (RICOH K.K) 14 March 1985 see abstract ----	9,10,12, 16
A	EP,A,0 043 721 (XEROX CORPORATION) 13 January 1982 see abstract; figures 1,3 ----	9,10,12, 16
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 351 (E-660)(3198) 20 September 1988 & JP,A,63 107 389 (TOSCHIBA CORP) 12 May 1988 see abstract ----	8,14,16
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 356 (E-459)(2412) 29 November 1986 & JP,A,61 154 390 (TOSHIBA CORP) 14 July 1986 see abstract ----	16
P,A	WO,A,9 215 036 (VLSI VISION LIMITED) 3 September 1992 cited in the application see page 2, line 11 - page 3, line 16; figure 1 -----	1,2

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

GB 9202260
SA 67353

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

24/03/93

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A-2240444	31-07-91	US-A- 5109158	28-04-92
EP-A-0248687	09-12-87	FR-A- 2598273	06-11-87
		CA-A- 1266523	06-03-90
		JP-A- 62263778	16-11-87
		US-A- 4760451	26-07-88
EP-A-0043721	13-01-82	CA-A- 1175360	02-10-84
		JP-A- 57041071	06-03-82
WO-A-9215036	03-09-92	None	

EPO FORM P0019

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

This Page Blank (uspto)